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The radionuclides of arsenic produced by
deuteron bombardment of germanium

Watters, Harry J.; Fagen, John F.

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Harry J. Watters

THE RADIONUCLIDES OF ARSENIC PRO-
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THE RADIOISOTOPES OF ARSENIC PRODUCED
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by

H. J. Watters, Lieutenant Commander, U. S. Navy**

and

J. F. Pagan, Jr., Lieutenant, U. S. Navy**

Department of Physics and Radioactivity Center of the
Laboratory for Nuclear Science, Massachusetts Institute
of Technology, Cambridge, Massachusetts

*This work has been supported in part by the joint
program of the ONR and AEC, and also in part by the Bureau
of Ordnance, U. S. Navy.

**Now on sea duty, U. S. Navy. Investigation performed
while a U. S. naval postgraduate student at Massachusetts
Institute of Technology, Cambridge, Massachusetts.

June 12, 1953

Note: Not a thesis, but a by-product of
their research. Prepared for publication
in Physical Review.

GRL

THE UNIVERSITY OF CHICAGO
DIVISION OF THE PHYSICAL SCIENCES

PH.D. THESIS OF
J. H. VAN VLIET

Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
in the Department of Physics
of the University of Chicago
by
J. H. VAN VLIET

Thesis prepared under the supervision of
Professor J. H. VAN VLIET
and
Professor J. H. VAN VLIET

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An investigation was made of the radionuclides of arsenic produced by the cyclotron bombardment of a thick germanium target with 15 Mev. deuterons. After chemical separation of the arsenic⁽¹⁾, identification of the isotopes present was made by correlating measured values of γ , β^+ , and total β half lives with maximum β energy and γ -ray energy.

Arsenic activity was measured continuously for a period of 53 days with a 4π proportional counter, a ν - γ coincidence counter, and with a thin end window Geiger Muller tube using calibrated aluminum absorbers. Gamma ray energy measurements were made using a thallium-activated sodium iodide scintillation spectrometer. The energy spectrum up to 3 Mev. was scanned continuously for the first 72 hours (Fig. 1) and an additional spectrum was obtained 52 days after bombardment.

By application of the method of least squares to 4π and coincidence counter data, the decay curves were analyzed in a total of four periods: 25.8 hours, 48.2 hours, 17.8 days and 33.9 days. Comparison of total β decay curves with those due only to positron disintegration yielded an additional period slightly greater than 70 hours. These values were verified by analysis of decay curves obtained with the end window β counter. The four experimental components shown in Fig. 2 were obtained from analysis of total β decay observed with the 4π counter.

(1) Brownell, G. L., E. W. Beckofen, E. F. White, and J. W. Irvine Jr., M. I. T. Progress Report May 1953, Contract AT(30-1)-

[illegible]

1. The first of these is the fact that the Commission has not yet received any information from the Government of the United States regarding the activities of the Committee for the Liberation of the People of the South (CLPS) in the United States. The Commission is therefore unable to provide any information on this matter.

[illegible][illegible]

The energy of the hardest γ -ray detected with the scintillation spectrometer was 0.85 Mev. with a half life of about 29 hours. An additional γ -ray energy of 0.60 Mev. was resolved several weeks after bombardment.

Maximum β energies were found from absorption curves obtained with the end window β counter. From measurements of maximum range made at various times, the energy of the most energetic β was determined for both the 25.8 hour and the 17.8 day isotopes. In addition mass absorption coefficients were determined from semilog plots of counting rate vs. absorber thickness taken at various times. Using these values, maximum β energies were computed for the 48.2 hour and the 17.8 day isotopes. Close agreement was found for the 17.8 day isotopes by both methods.

Correlation of data indicated that the nuclidic mixture consisted of As^{71} , As^{72} , As^{73} , As^{74} , and As^{77} . Due to the absence of γ -ray energies greater than 0.85 Mev. it was concluded that As^{76} was not present in the mixture.

Since the efficiency of the 4π solid angle β counter constructed for this investigation was shown to be very nearly 100 percent for particles which escape the source, these data were used to determine absolute β activities. These activities were corrected to the time of completion of bombardment and the results specified in terms of yield for each isotope.

The energy of the highest γ -ray detected after the
irradiation was 0.53 Mev. with a half life of
about 10 hours. An additional γ -ray energy of 0.55 Mev. was
detected several weeks after irradiation.

Exposure to γ -rays was found from absorption curves
obtained with the same window β counter. From measurements of
various known rods of various sizes, the energy of the γ -ray
was determined to be 0.53 Mev. and the β -ray was found to be
0.55 Mev. In addition some absorption measurements were
obtained from various rods of various sizes vs. exposure
time. These data are shown in Figure 1. Using these values, various
calculations were made for the β -ray and the γ -ray
isotope. The results are shown in Table I for the β -ray isotope
and in Table II for the γ -ray isotope.

Comparison of the results of the two methods shows
that the β -ray isotope is ^{137}Cs , ^{137}Ba , and ^{137}La . Due to the
presence of γ -ray isotope, the β -ray isotope is ^{137}Cs . It is
assumed that the γ -ray isotope is ^{137}Cs .
Since the absorption of the γ -ray isotope is constant
independent of the β -ray isotope, it was assumed that the β -ray isotope
was ^{137}Cs . The β -ray isotope was found to be ^{137}Cs . These results
are shown in Table III. The β -ray isotope is ^{137}Cs .
The results are shown in Table IV for each isotope.

The following is a tabular summary of the results of this investigation:

<u>Isotope</u>	<u>Method of decay</u>	<u>Energy (MeV)</u>	<u>T_{1/2}*</u>	<u>Thick target yield** (uc/uamp-hr)</u>
As ⁷¹	β ⁺	0.66	48.2 ± 1.2 hrs.	7.6
As ⁷²	β ⁺	3.25	25.8 ± 0.2 hrs.	64.9
	γ	0.83		
As ⁷³	β ⁻	0.11 > E _{max} > 0.02	86.9 ± 9.2 days	1.1
As ⁷⁴	β ⁺	0.99, 1.49	17.82 ± 0.13 days	5.2
	β ⁻			
As ⁷⁶		Not present in the mixture		
As ⁷⁷	β ⁻	< 0.7	> 70 hours	5 < yield < 15***

* Half lives are stated with their respective standard errors.

** The thick target yield values specified apply if the deuteron beam current was exactly 36 uamps and if the arsenic separation efficiency was 100 percent. Yield values quoted are based on β counting only and do not include orbital electron capture.

*** Based on ratios of total β to β^+ counting rates.

The following is a list of the results of the analysis of the samples of the material.

Sample No.	Weight (g)	Volume (ml)	Concentration (%)	Notes
1	10.0	10.0	10.0	
2	10.0	10.0	10.0	
3	10.0	10.0	10.0	
4	10.0	10.0	10.0	
5	10.0	10.0	10.0	
6	10.0	10.0	10.0	
7	10.0	10.0	10.0	
8	10.0	10.0	10.0	
9	10.0	10.0	10.0	
10	10.0	10.0	10.0	

The results of the analysis of the samples of the material are shown in the table above. The concentration of the material is 10.0% for all samples. The weight and volume of the samples are also shown. The results of the analysis are as follows:

The Master's thesis "An Investigation of the Radionuclides of Arsenic Produced by Cyclotron Bombardment of Germanium with 15 Mev. Deuterons" submitted by these writers to the Massachusetts Institute of Technology contains details of the investigation and a complete treatment of the construction and operating technique of the 473 counter. This investigation was suggested by Dr. Gordon L. Brownell of the Massachusetts General Hospital and was conducted under the supervision of Prof. Pohley D. Evans.

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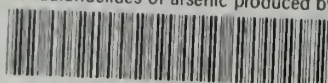
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